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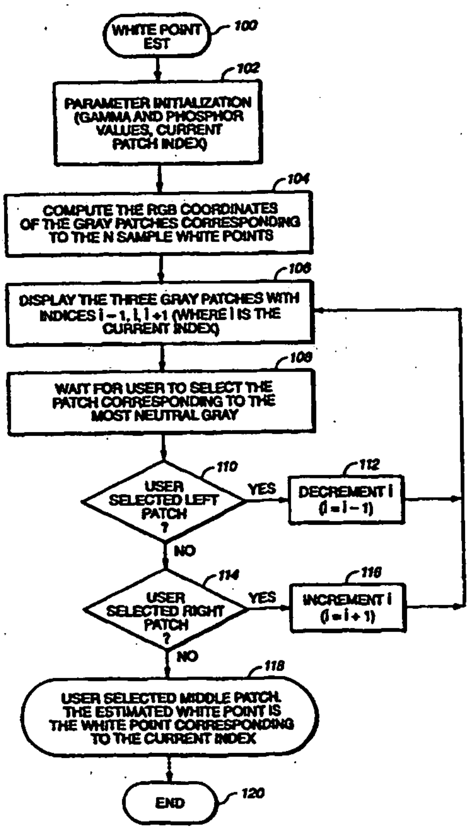
(54) Title: METHOD TO ESTIMATE THE WHITE POINT ON A DISPLAY DEVICE

(57) Abstract

Methods and apparatus for estimating a white point of a display device (100) include displaying a plurality of gray patches on a display screen of the display device (106); requesting that a user select a patch corresponding to a neutral gray (108); and iteratively converging (112 and 116) to a patch where the estimated white point is the most neutral gray point (118).



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METHOD TO ESTIMATE THE WHITE POINT ON A DISPLAY DEVICE

BACKGROUND

The present invention relates to the field of digital image processing, and more particularly to color calibration and color enhancement for digital imaging systems.

Continual advances in computer technology are making possible cost effective color digital imaging systems capable of displaying high resolution images. The proliferation of these imaging systems is driving a need for predictable color matching between the image scanner, the display, and the hard copy devices. In color digital imaging, each aspect of the imaging chain, including the lighting of the original scene as well as the capturing, storage, transmission, and display of the image on screen or hard copy devices, generally involves different color spaces in conjunction with different color gamuts. Most of the color spaces are device dependent. A color gamut is the range of colors which can be reproduced on a particular device. In this context, accurate descriptions of how various devices in a typical work flow represent color are required.

One method to ensure consistent color characteristics is to calibrate the color display and hard copy devices to particular set up parameters. A description of a device with respect to the way it represents color is stored in a "profile" of that device. Based on the type of the device, certain parameters are required in order to characterize the device completely and accurately. For example, in the case of display

devices, these parameters include the X, Y, and Z coordinates of the media white point; the relative X, Y, Z values corresponding to red, green and blue; and the red, green and blue tone reproduction curves. The XYZ values are the three standard primary colors of the CIE chromaticity diagram. Once all devices involved in a particular work flow are appropriately characterized by the corresponding profiles, color management systems can be used to convert colors from the color space of one device to the color space of another device, therefore leading to consistent color reproduction across the devices as well as operating system platforms.

Several products are currently available for accurately measuring the characteristics of various display and hard copy devices. With the aid of such tools, the user can display an image having known color characteristics and manually calibrate the display screen to produce known characteristics of the image on a display screen or on a hard copy device. However, since most computer users do not have access to relatively expensive measurement and calibration equipment, these users generally resort to an alternate solution of using a software tool in conjunction with a physical template whose brightness and hue are compared and matched to that of the display. However, the use of the matching template is not optimal as the screen and the template are made from different media (emissive versus reflective). Additionally, software tools in this category require that a template be readily available for comparison purposes.

SUMMARY OF THE INVENTION

The invention provides apparatus and methods implementing a technique for estimating the white point

of a display device.

In general, in one aspect, the technique includes displaying a plurality of grey patches on a screen; requesting that a user select a patch corresponding to a neutral grey; and iteratively converging to a patch where the estimated white point is the most neutral grey point.

In general, in another aspect, the technique includes displaying an image on a screen of a display device, and deriving an estimate of the white point of the display device solely on the basis of a user's response to the displayed image and without comparison to an external reference, the estimate of the white point being the coordinates of the estimate on a chromaticity diagram.

Advantageous implementations of the invention include one or more of the following features. Gamma and phosphor values are set to selected initial values. Each grey patch is associated with an index, and the index is incremented or decremented in accordance with a user selection. Parameter initialization includes dividing the white point's axis into n samples whose corresponding correlated color temperatures range between 4500°K and 10000°K; setting a gamma value to the display's gamma value; setting phosphor values to the display's phosphor values; setting a current sample to a point where the correlated temperature is 6500°K; and setting the current index to the index of a current sample. Red green blue (RGB) coordinates of each grey patch are computed, each patch corresponding to one of the n sample white points. This computation can include assuming the white point of the display device corresponds to the i-th sample; generating a reference XYZ vector using a 7500°K correlated color temperature; computing an XYZ-to-RGB

transformation matrix based on a current white point and phosphor setting; applying the XYZ-to-RGB transformation to the reference XYZ vector; correcting the gamma values of a reference RGB vector, using the current gamma values; and mapping the RGB values to a color range.

Advantages of the invention include the following. The invention provides color calibration less expensively than color measuring equipment. Moreover, the invention is a software tool that does not require any special hardware besides the computer itself. Physical templates are not needed. The invention also obviates the need for matching colors in different media. The invention also does not require detailed knowledge of color science in order to perform color calibration.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flow chart of a white point estimation process.

Figure 2 is a flow chart of a parameter initialization process

Figure 3 is a flow chart of an RGB coordinate determination process.

Figure 4 is an illustration of a computer system.

DESCRIPTION

Referring now to Figure 1, a white point estimation process 100 is shown. First, the process 100 initializes gamma and phosphor values as well as a current patch index (step 102). Next, the process 100 computes RGB coordinates of the grey patches corresponding to n sample white points (step 104). Next, the process 100 displays three grey patches with indices i-1, i, i+1, where i is the current index (step 106). Ideally, the grey patches are displayed on a completely black screen background in the absence of any light

sources shining on the screen. The process 100 then waits for a user to select the patch appearing to have the most neutral grey color (step 108).

Next, the process 100 determines whether the user has selected a left patch (step 110). If so, the current index i is decremented (step 112) and the process loops back to step 106. If the user has selected a right patch (step 114), the current index i is incremented (step 116) before the process 100 loops back to step 106. If the user selected the middle patch, the process 100 proceeds to step 118. The estimated white point is the white point corresponding to the current index, that is, the white point used to calculate the RGB coordinates of the selected grey patch. Finally, the process 100 exits (step 120). In an alternative embodiment, when the middle patch is selected, new left and right patches are created from sample white points closer to the white point of the middle patch, until a minimum distance is reached.

Turning now to Figure 2, the parameter initialization process associated with step 102 is shown in more detail. The process divides the white point axis in the chromaticity diagram into n samples whose corresponding correlated color temperatures range between 4500°K and 10000°K (step 132). Each sample is therefore associated with an index pointing to the array of n samples, a correlated color temperature T_i of the i-th sample, a set of chromaticity coordinates (x_i^T, y_i^T) of the i-th sample at the correlated temperature T_i.

Next, the process sets a gamma parameter to the monitor gamma value (step 134). Then, the phosphor values are set to the monitor phosphor values (step 136). The process of Figure 3 sets the current sample to the

sample with a correlated color temperature of 6500°K (step 138). The index is then set to the index of the current sample (step 140) before the process exits (step 142).

Referring now to Figure 3, a process for determining the RGB coordinates of step 104 is shown in more detail. First, the process sets the white point to the point corresponding to the i-th sample (x_i^t, y_i^t) (step 152). Next, the process computes a reference XYZ vector using the XYZ coordinates corresponding to the correlated color temperature of 7500°K scaled so that luminance value Y is set to 0.5 (step 154). For example, if the reference XYZ vector has the following values: $X_r = 0.9495$; $Y_r = 1.0$; and $Z_r = 1.2251$, the scaled reference XYZ vector is: $X_r = 0.47475$; $Y_r = 0.5$; and $Z_r = 0.61255$.

Then, the process computes the XYZ-to-RGB transformation matrix $\underline{M}$ based on the current white point and phosphor settings (step 156). In the XYZ to RGB transformation matrix, the white point chromaticity is denoted (w_x, w_y), while the red, green and blue phosphors are denoted as (r_x, r_y), (g_x, g_y) and (b_x, b_y). The Z values may be derived by using the equation

$$Z = 1 - X - Y.$$

Next, the following operations are performed:

$$\underline{W} = [X_w \; Y_w \; Z_w] = \begin{bmatrix} \frac{w_x}{w_y} & 1 & \frac{w_z}{w_y} \end{bmatrix}$$

$$\underline{K}=\begin{pmatrix} r_x & r_y & r_z \\ g_x & g_y & g_z \\ b_x & b_y & b_z \end{pmatrix}$$

$$\underline{V} = \underline{W} \cdot \underline{K}^{-1}$$

$$\underline{V}=[V_r \; V_g \; V_b]$$

$$\underline{G}=\begin{pmatrix} V_r & 0 & 0 \\ 0 & V_g & 0 \\ 0 & 0 & V_b \end{pmatrix}$$

$\underline{N} = \underline{G} \cdot \underline{K}$; and
$\underline{M} = \underline{N}^{-1}$.

Then, the 7500°K scaled reference XYZ vector $\underline{C}_{XYZ}$ is converted into a corresponding RGB vector $\underline{C}_{RGB}$ by applying the $\underline{M}$ transformation (step 158):

$$\underline{C}_{RGB} = \underline{C}_{XYZ} \cdot \underline{M}.$$

Then, using the current gamma value γ, the process of Figure 3 corrects the gamma of the reference RGB vector $\underline{C}_{RGB}$ obtained in step 158 to produce a

gamma-corrected RGB vector $\underline{C}'_{RGB}$ as follows (step 160):

$$\underline{C}'_{RGB} = \underline{C}^{1/\gamma}_{RGB}.$$

The process of Figure 3 then scales the gamma-corrected RGB values from the 0..1 range, which includes fractional values, to a range of values suitable for driving the display device. This is typically a range of integers from 0 to 255 for each RGB color component, which is calculated as follows (step 162):

$$\underline{C}''_{RGB} = \text{INTEGER\_PART}\left(\left(\underline{C}'_{RGB} \cdot 255.0\right) + 0.5\right).$$

INTEGER_PART is a function that truncates its argument to an integer value. The result is $\underline{C}''_{RGB}$, a vector of the gamma-corrected RGB coordinates of the grey patch for the current sample white point. Having calculated this, the process exits (step 164).

The techniques described here may be implemented in hardware or software, or a combination of the two. Preferably, the techniques are implemented in computer programs executing on programmable computers that each includes a processor, a storage medium readable by the processor (including volatile and nonvolatile memory and/or storage elements), and suitable input and output devices. Program code is applied to data entered using an input device to perform the functions described and to generate output information. The output information is applied to one or more output devices.

Figure 4 illustrates one such computer system 600, including a CPU 610, a RAM 620, a ROM 622 and an I/O controller 630 coupled by a CPU bus 640. The I/O controller 630 is also coupled by an I/O bus 698 to input devices such as a keyboard 660 and a mouse 670, and output devices such as a monitor 680. The I/O controller 630 also drives an I/O interface 690 which in turn controls a removable disk drive 692 such as a floppy disk, among others.

Variations are within the scope of the following claims. For example, instead of using a mouse as the input devices to the computer system 600, a pressure-sensitive pen or tablet may be used to generate the cursor position information. Moreover, each program is preferably implemented in a high level procedural or object-oriented programming language to communicate with a computer system. However, the programs can be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language.

Each such computer program is preferably stored on a storage medium or device (e.g., CD-ROM, hard disk or magnetic diskette) that is readable by a general or special purpose programmable computer for configuring and operating the computer when the storage medium or device is read by the computer to perform the procedures described. The system also may be implemented as a computer-readable storage medium, configured with a computer program, where the storage medium so configured causes a computer to operate in a specific and predefined manner.

The invention has been described in terms of particular embodiments. Other embodiments are within the

scope of the following claims. For example, the order of performing steps of the invention can be changed by those skilled in the art and still achieve desirable results. The number or arrangement of grey patches can be changed. The grey patches can be arranged in a series of steps or stairs. Alternatively, a series of thin grey patches or lines may be displayed on the screen and the user may select the thin grey patches or grey lines using a number of standard selection user interface. For example, the user can simply click on the appropriate patch or line, or the user may select the patch or line by scrolling a dial interface or bar interface, among others. The RGB coordinates of grey patches can be calculated as needed. The RGB coordinates of grey patches can be calculated using a reference vector having a color temperature other than 7500°K. The iteration to a final selection by the user of a neutral grey patch can include changing the amount by which the displayed grey patches differ from each other as the process converges to a neutral grey color.

What is claimed is:

1. A method for estimating a white point, comprising:

displaying a plurality of grey patches on a display screen of a display device;

requesting that a user select one of the plurality of grey patches having a neutral grey color; and

iterating the steps of displaying grey patches and requesting user selection to converge to a grey patch where the estimated white point is the most neutral grey point.

2. The method of claim 1, further comprising:

dividing a white point axis of a chromaticity diagram into n samples whose corresponding correlated color temperatures range between 4500°K and 10000°K;

setting a gamma value to the display's gamma value;

setting phosphor values to the display's phosphor values;

setting a current sample to a point where the correlated temperature is 6500°K; and

displaying a current grey patch according to the gamma and phosphor values and the current sample.

3. The method of claim 1 or 2, further comprising computing red green blue (RGB) coordinates of a grey patch corresponding to one of n sample white points on a chromaticity diagram.

4. The method of claim 1, 2, or 3, wherein computing RGB coordinates of a grey patch comprises:

initializing gamma and phosphor values;

selecting a current white point corresponding to an

i-th sample of n sample white points on a chromaticity diagram;

generating a reference XYZ vector using a 7500°K correlated color temperature;

computing an XYZ-to-RGB transformation based on the current white point and phosphor values;

applying the XYZ-to-RGB transformation to the reference XYZ vector to create a reference RGB vector;

applying a gamma correction to the reference RGB vector; and

mapping the gamma-corrected RGB values to a range of values suitable for driving the display device.

5. The method of claim 4, further comprising:

scaling the XYZ reference vector to have a luminance value Y in a range between 0 and 1 before creating the reference RGB vector.

6. The method of claim 1, 2, or 3, wherein a white point chromaticity is denoted (w_x, w_y), values for red, green and blue phosphors are denoted (r_x, r_y), (g_x, g_y) and (b_x, b_y), and Z has a value 1-X-Y, the method further comprising:

determining

$$\underline{W} = [X_w \; Y_w \; Z_w] = \begin{bmatrix} \dfrac{w_x}{w_y} & 1 & \dfrac{w_z}{w_y} \end{bmatrix};$$

determining

$$\underline{K} = \begin{pmatrix} r_x & r_y & r_z \\ g_x & g_y & g_z \\ b_x & b_y & b_z \end{pmatrix};$$

determining

$$\underline{V} = \underline{W} \cdot \underline{K}^{-1}$$

determining

$$\underline{V} = [V_r \; V_g \; V_b];$$

determining

$$\underline{G} = \begin{pmatrix} V_r & 0 & 0 \\ 0 & V_g & 0 \\ 0 & 0 & V_b \end{pmatrix};$$

determining $\underline{N} = \underline{G} \cdot \underline{K}$;
determining $\underline{M} = \underline{N}^{-1}$; and

converting a 7500°K scaled reference XYZ vector $\underline{C}_{XYZ}$ into a vector of RGB coordinates $\underline{C}_{RGB}$ in accordance with

$$\underline{C}_{RGB} = \underline{C}_{XYZ} \cdot \underline{M} .$$

7. The method of claim 1, 2, 3, or 6, wherein the grey patches are displayed on a black screen background in the absence of light shining on the screen.

8. A computer program stored on a computer-readable medium for estimating a white point, the program comprising instructions to:

display a plurality of grey patches on a display screen of a display device;

request that a user select one of the plurality of grey patches having a neutral grey color; and

iterate the steps of displaying grey patches and requesting user selection to converge to a patch where the estimated white point is the most neutral grey point.

9. The program of claim 8, further comprising instructions to:

divide the white point axis of a chromaticity diagram into n samples whose corresponding correlated color temperatures range between 4500°K and 10000°K;

set a gamma value to the display's gamma value;

set phosphor values to the display's phosphor values;

set a current sample to a point where the correlated temperature of 6500°K; and

display a current grey patch according to the gamma

and phosphor values and the current sample.

10. The program of claim 8 or 9, further comprising instructions to compute red green blue (RGB) coordinates of a grey patch corresponding to one of n sample white points on a chromaticity diagram.

11. The program of claim 8, 9, or 10, wherein the RGB coordinate computing instructions further comprises instructions to:

initialize gamma and phosphor values;

select a current white point corresponding to an i-th sample of n sample white points on a chromaticity diagram;

generate a reference XYZ vector using a 7500°K correlated color temperature;

compute an XYZ-to-RGB transformation based on the current white point and phosphor values;

apply the XYZ-to-RGB transformation to the reference XYZ vector to create a reference RGB vector;

apply a gamma correction to the reference RGB vector; and

map the gamma-corrected RGB values to a range of values suitable for driving the display device.

12. The program of claim 11, further comprising instructions to:

scale the XYZ reference vector to have a luminance value Y = 0.5 before creating the reference RGB vector.

13. The program of claim 8, 9, or 11, wherein a white point chromaticity is denoted (w_x, w_y), values for red, green and blue phosphors are denoted as (r_x, r_y), (g_x, g_y)

and (b_x, b_y), and Z values generated as 1 - X -Y, further comprising instructions to:

determine

$$\underline{W} = [X_w\ Y_w\ Z_w] = \left[\frac{w_x}{w_y}\ \ 1\ \ \frac{w_z}{w_y}\right];$$

determine

$$\underline{K} = \begin{pmatrix} r_x & r_y & r_z \\ g_x & g_y & g_z \\ b_x & b_y & b_z \end{pmatrix};$$

determine

$$\underline{V} = \underline{W} \cdot \underline{K}^{-1}$$

determine

$$\underline{V}=[V_r\ V_g\ V_b];$$

determine

$$\underline{G}=\begin{pmatrix} V_r & 0 & 0 \\ 0 & V_g & 0 \\ 0 & 0 & V_b \end{pmatrix};$$

determine $\underline{N} = \underline{G} \cdot \underline{K}$;

determine $\underline{M} = \underline{N}^{-1}$; and

convert a 7500°K scaled reference XYZ vector $\underline{C}_{XYZ}$ into a vector of RGB coordinates $\underline{C}_{RGB}$ in accordance with

$$\underline{C}_{RGB} = \underline{C}_{XYZ} \cdot \underline{M} .$$

14. The program of claim 8, 9, 10, or 13, wherein the grey patches are displayed on a black screen background in the absence of light shining on the screen.

15. In a system having a display device with a display screen, a subsystem for estimating a white point, comprising:

means for displaying a plurality of grey patches on the display screen of the display device;

means for requesting that a user select one of the plurality of grey patches having a neutral grey color; and

means for iteratively displaying grey patches and requesting user selections to converge to a grey patch where the estimated white point is the most neutral grey point.

16. The system of claim 15, further comprising:

means for dividing a white point axis of a chromaticity diagram into n samples whose corresponding correlated color temperatures range between 4500°K and 10000°K;

means for setting a gamma value to the display's gamma value;

means for setting phosphor values to the display's phosphor values;

means for setting a current sample to a point where the correlated temperature is 6500°K; and

means for displaying a current grey patch according to the gamma and phosphor values and the current sample.

17. The system of claim 15 or 16, further comprising means for computing red green blue (RGB) coordinates of a grey patch corresponding to one of n sample white points on a chromaticity diagram.

18. The system of claim 15, 16, or 17, wherein computing RGB coordinates of a grey patch comprises:

means for initializing gamma and phosphor setting values;

means for selecting a current white point corresponding to an i-th sample of n sample white points on a chromaticity diagram;

means for generating a reference XYZ vector using a 7500°K correlated color temperature;

means for computing an XYZ-to-RGB transformation based on the current white point and phosphor values;

means for applying the XYZ-to-RGB transformation to the reference XYZ vector to create a reference RGB vector;

means for applying a gamma correction to the reference RGB vector; and

means for mapping the gamma-corrected RGB values to a range of values suitable for driving the display device.

19. The system of claim 18, further comprising:

means for scaling the XYZ reference vector to have a luminance value Y = 0.5 before creating the reference RGB vector.

20. The system of claim 15, 16, or 17, wherein a white point chromaticity is denoted (w_x, w_y), values for red, green and blue phosphors are denoted (r_x, r_y), (g_x, g_y) and (b_x, b_y), and Z has a value 1-X-Y, the system further comprising:

means for converting a 7500°K scaled reference XYZ vector $\underline{C}_{XYZ}$ into a vector of RGB coordinates $\underline{C}_{RGB}$ in accordance with $\underline{C}_{RGB} = \underline{C}_{XYZ} \cdot \underline{M}$, where $\underline{M}$ is calculated in accordance with the following equations:

$$\underline{W} = [X_w \; Y_w \; Z_w] = \begin{bmatrix} \frac{w_x}{w_y} & 1 & \frac{w_z}{w_y} \end{bmatrix};$$

$$\underline{K} = \begin{pmatrix} r_x & r_y & r_z \\ g_x & g_y & g_z \\ b_x & b_y & b_z \end{pmatrix};$$

$$\underline{V} = \underline{W} \cdot \underline{K}^{-1};$$

$$\underline{V}=[V_r\ V_g\ V_b];$$

$$\underline{G} = \begin{pmatrix} V_r & 0 & 0 \\ 0 & V_g & 0 \\ 0 & 0 & V_b \end{pmatrix};$$

$$\underline{N} = \underline{G} \cdot \underline{K};$$

and

$$\underline{M} = \underline{N}^{-1}.$$

21. The system of claim 15, 16, 17, or 20, wherein the grey patches are displayed on a black screen background in the absence of light shining on the screen.

22. A method for estimating a white point of a display device, comprising:

displaying an image on a screen of a display device;

deriving an estimate of the white point of the display device solely on the basis of a user's response to the displayed image and without comparison to an external reference, the estimate of the white point being the coordinates of the estimate on a chromaticity diagram.

23. The method of claim 22 wherein the white point estimate coordinates are XYZ values in a CIE chromaticity diagram.

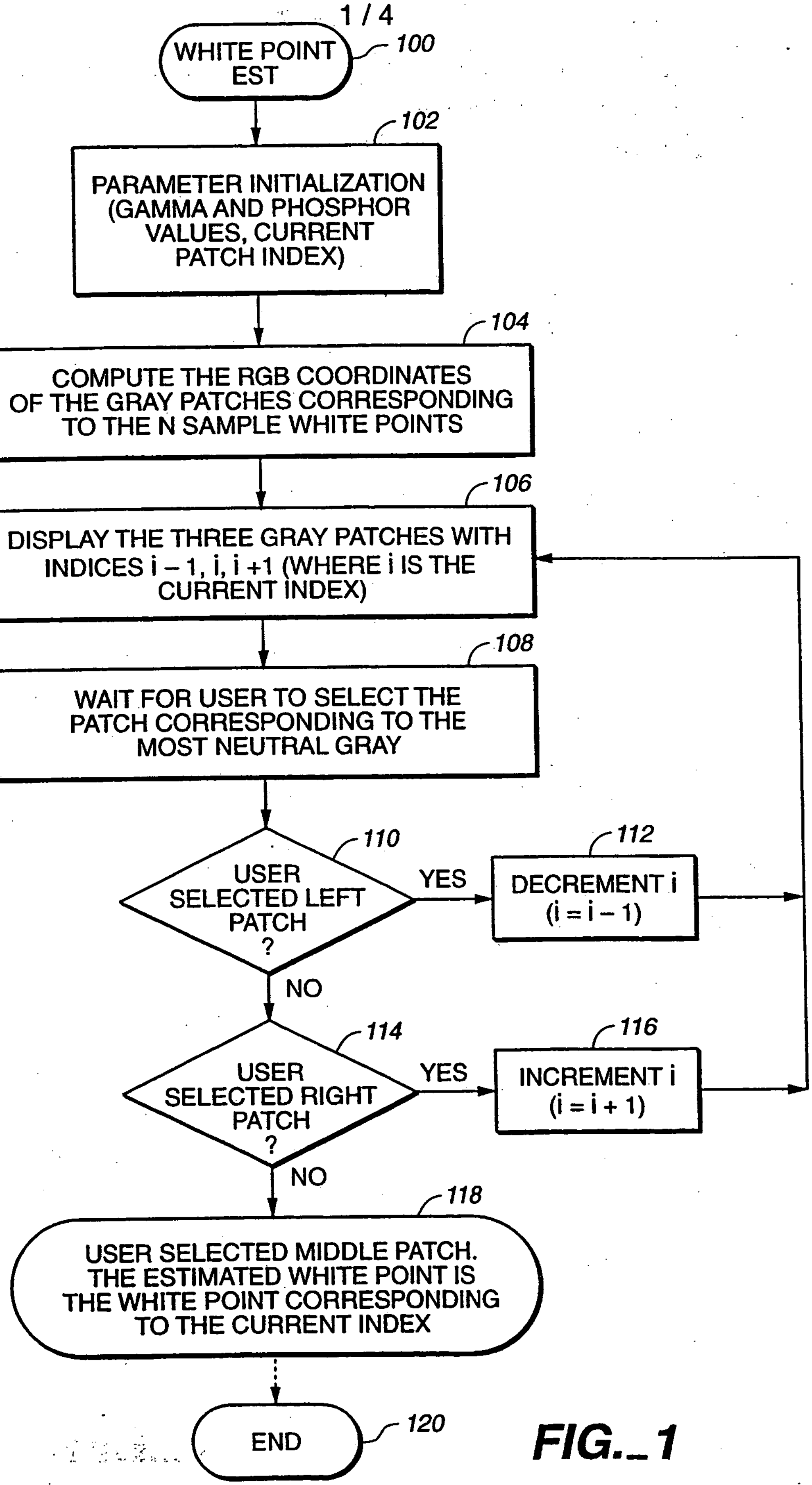

FIG._1

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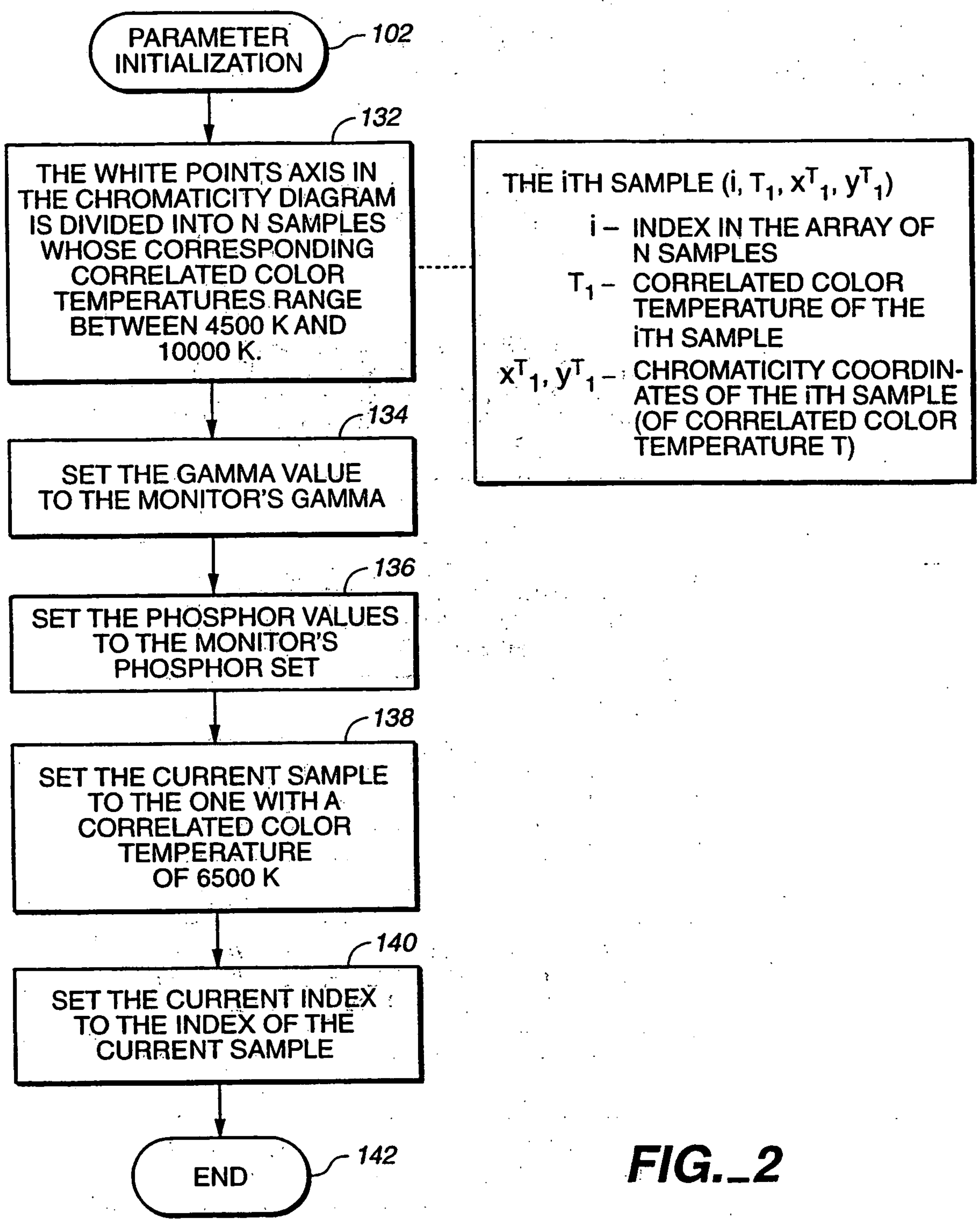
PARAMETER INITIALIZATION
102
132
THE WHITE POINTS AXIS IN THE CHROMATICITY DIAGRAM IS DIVIDED INTO N SAMPLES WHOSE CORRESPONDING CORRELATED COLOR TEMPERATURES RANGE BETWEEN 4500 K AND 10000 K.
THE iTH SAMPLE (i, T_1, $x^T{}_1$, $y^T{}_1$)
i – INDEX IN THE ARRAY OF N SAMPLES
T_1 – CORRELATED COLOR TEMPERATURE OF THE iTH SAMPLE
$x^T{}_1$, $y^T{}_1$ – CHROMATICITY COORDINATES OF THE iTH SAMPLE (OF CORRELATED COLOR TEMPERATURE T)
134
SET THE GAMMA VALUE TO THE MONITOR'S GAMMA
136
SET THE PHOSPHOR VALUES TO THE MONITOR'S PHOSPHOR SET
138
SET THE CURRENT SAMPLE TO THE ONE WITH A CORRELATED COLOR TEMPERATURE OF 6500 K
140
SET THE CURRENT INDEX TO THE INDEX OF THE CURRENT SAMPLE
END
142

FIG._2

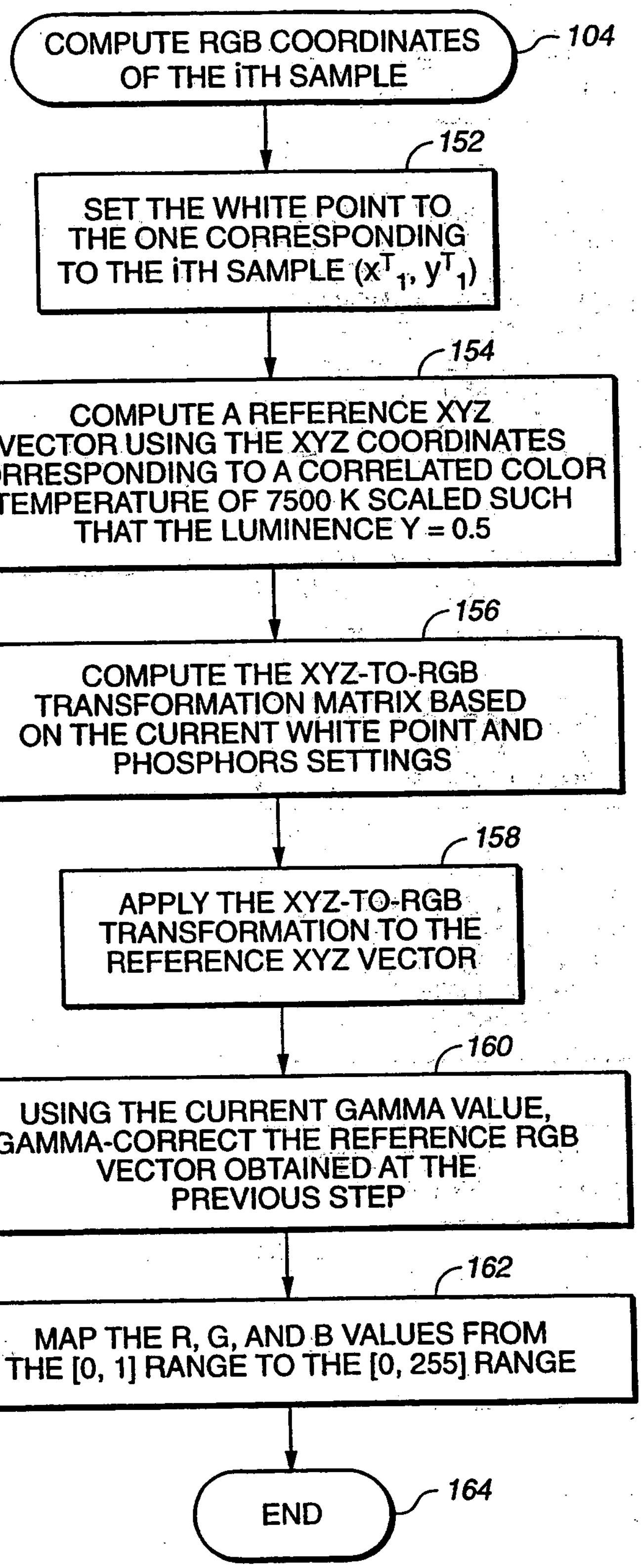
COMPUTE RGB COORDINATES OF THE iTH SAMPLE
104
152
SET THE WHITE POINT TO THE ONE CORRESPONDING TO THE iTH SAMPLE (x^T_1, y^T_1)
154
COMPUTE A REFERENCE XYZ VECTOR USING THE XYZ COORDINATES CORRESPONDING TO A CORRELATED COLOR TEMPERATURE OF 7500 K SCALED SUCH THAT THE LUMINENCE Y = 0.5
156
COMPUTE THE XYZ-TO-RGB TRANSFORMATION MATRIX BASED ON THE CURRENT WHITE POINT AND PHOSPHORS SETTINGS
158
APPLY THE XYZ-TO-RGB TRANSFORMATION TO THE REFERENCE XYZ VECTOR
160
USING THE CURRENT GAMMA VALUE, GAMMA-CORRECT THE REFERENCE RGB VECTOR OBTAINED AT THE PREVIOUS STEP
162
MAP THE R, G, AND B VALUES FROM THE [0, 1] RANGE TO THE [0, 255] RANGE
END
164

FIG._3

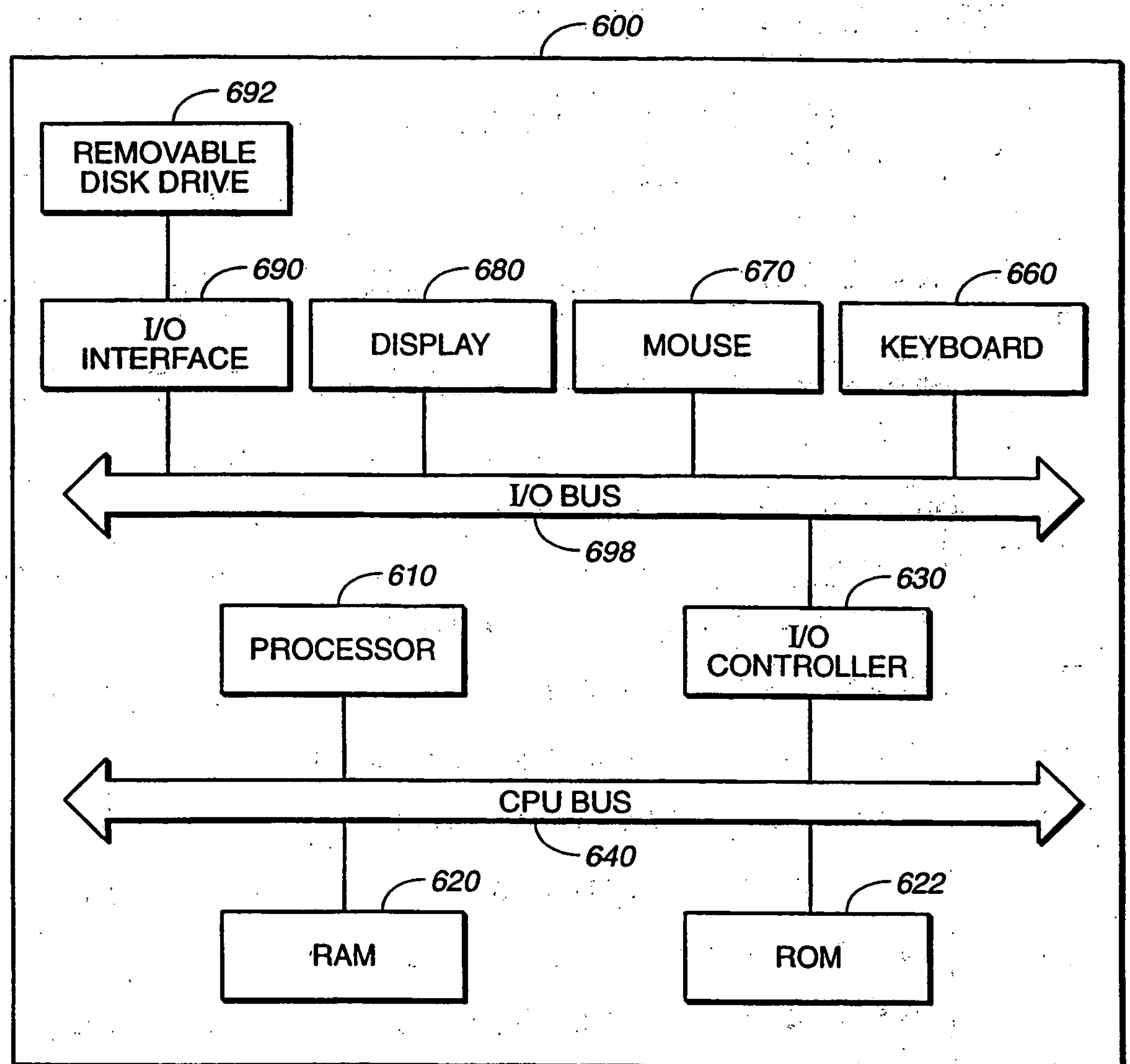
600
692
REMOVABLE DISK DRIVE
690
I/O INTERFACE
680
DISPLAY
670
MOUSE
660
KEYBOARD
I/O BUS
698
610
PROCESSOR
630
I/O CONTROLLER
CPU BUS
640
620
RAM
622
ROM

FIG._4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/15707

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL :345/22, 147; 348/184; 355/32; 358/80, 501, 504, 518; 364/571.01
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 345/22, 147; 348/184; 355/32; 358/80, 501, 504, 518; 364/571.01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
APS, West
search terms: white point, color temperature, grey, neutral, patch, pattern, block, calibrate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US 5,754,222 A (DALY ET AL) 19 May 1998	1-23
A	US 5,528,339 A (BUHR ET AL) 18 June 1996	1-23
A	US 5,363,318 A (MCCAULEY) 08 November 1994	1-23
A	US 5,081,529 A (COLLETTE) 14 January 1992	1-23
A	US 5,172,224 A (COLLETTE ET AL) 15 December 1992	1-23
A	US 5,334,992 A (ROCHAT ET AL) 02 August 1994	1-23
A	US 5,596,428 A (TYTGAT ET AL) 21 January 1997	1-23
A	US 5,313,291 A (APPEL ET AL) 17 May 1994	1-23

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"B" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
23 OCTOBER 1998

Date of mailing of the international search report
16 JUN 1999

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,583,666 A (ELLSON ET AL) 10 December 1996	1-23
A	US 5,694,227 A (STARKWEATHER) 02 December 1997	1-23
A	Henry Kaug, "Color Technology for Electronic Imaging Devices," SPIE Press, 125-130, 1997	1-23
A	Foley et al., "Chromatic Color," Addison Wesley, 578-585, 1992	1-23
A	"Calibrating Your Monitor," The Unofficial Spectator, www.designimg.com/flashnet/tus/tuscal.html, 1997	1-23
A	"Monitor Calibration," Phototech Imaging, www.varis.com/Technique/MonitorCalibration.html, 1998	1-23
A	Brian Young, "Monitor Calibration," Sim Video Productions Ltd., www.simvideo.ca/simsite/monitor_cal.html, 1998	1-23
A	"Monitor Calibration," North Hills Radio Club Inc., www.ns.net/~NHRC/cal.html, 1998	1-23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/15707

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

G01D 18/00; G02B 7/00; G03F 3/08; G09G 1/28; H04N 17/02, 1/46, 1/60

Form PCT/ISA/210 (extra sheet)(July 1992)★